DIGITAL EQUIPMENT CORPORATION

education

Computer Managed Instruction (CMI)

computers are for kids — digital — EduSystems—expandable, economical

CAPSULE SUMMARY

Computer Managed Instruction (CMI) is a method for the efficient management of a curriculum using individualized programmed instructional text materials.

Students are taught both by teachers (about 50% of the time) and by executing frames in programmed instructional textbooks. Every 200 or 300 frames the student takes an achievement test (using an optical mark test form).

The computer immediately grades his test in the classroom and keeps a record of his score. Based on his performance, he may go on with the next set of frames, do a set of remedial frames or receive tutorial help from a teacher. In the latter two cases, he could ultimately retake a similar, but different, achievement test.

Each student proceeds at his own pace until he has completed all of the instructional "strands" which may, depending upon the material used, cover from one to six years in one or more subject areas.

In addition to scoring and recording the tests, the computer also keeps a comprehensive record of all students, provides periodic reports on progress and achievement, identifies exceptional cases and analyses tests and test questions.

CMI may be used with cluster or traditional schedules. It may also be used as a part of any testing program to compare achievement of students. It is probably the most thorough measuring device for "accountability" when used in conjunction with pre-determined behaviorial objectives and validated tests.

The computer also provides terminals for remedial drill and practice, student problem solving and simulation exercises.

COMPUTER MANAGED INSTRUCTION (CMI)

Introduction

Imagine that you and 25 other patients are waiting in the doctor's office. The doctor appears. He explains that he won't have time to see you all individually, so he'll just give each of you a flu shot because that's probably what you need.

Ridiculous? Of course! It wouldn't happen.

Yet a similar kind of group prescription is happening all the time in many of our schools. One of the most basic and most generally accepted goals of educators is the creation of a school environment which allows each student to learn according to his individual rate and capacity. Until the advent of the computer, the non-professional, clerical chores required to structure such an environment have made its implementation prohibitive. However, by having the computer perform most of the bookeeping, teachers have more time to concentrate on individualized and personalized instruction for their students.

One obvious advantage of such an environment is its fluid structure which allows continual allocation of resources (teachers and classrooms) to meet the needs of the students rather than the traditional method which assigns students to a single teacher and classroom for the entire school term. The availability of information on student progress and performance makes possible the evaluation of individual student needs with the capability to provide for these needs. Classes can be organized on the basis of student need to provide remedial work for those who need it and for enrichment programming for those achieving above their grade level. This evaluative capability can be utilized as often as the teacher feels is necessary with the resultant educational system catering to students rather than the other way around.

DEC's CMI system is flexibly designed so as to function with any commercially available programmed instructional (PI) materials at any grade level. The system may also be used for rapid test grading analysis, and reporting of data within the traditional curricula. Highly-trained operators are not necessary nor do students or teachers have to learn anything about the computer hardware in order to utilize the system.

What is Programmed Instruction?

A programmed course consists of a numbered sequence of sentences or paragraphs each, in the jargon of the field, called a "frame." One or more times within each "frame", a "blank" provides for the interaction of the student with the material he is reading. After this interaction has been completed, a previously concealed "correct response" is revealed so that the student receives, immediately, a reinforcement of a correct response or a "blocking" of an incorrect one. All of the detailed discourse regarding "programs" can be condensed into four statements which establish the value of this material:

1) Material written especially to communicate ideas to students, with sufficient planned repetition and review to fix these ideas.

2) Provision for constant participation of the student in the reading-learning process.

3) Provision for immediate checking of responses, with the valuable reinforcement or blocking which this provides.

4) Provision to accommodate individual differences since progress can be at the student's own rate.

What is the Role of the Teacher?

"What do I, as a teacher, do in a class which is using programmed material?" Since individual students differ, the teacher's role will vary greatly from one such class to another. No attempt will be made to write a "classroom procedures manual." However, information provided by many teachers who have experience with this material can serve to define certain "guidelines."

A) It is important that proper student attitudes toward the material be established early and maintained throughout the course. Misconceptions disastrous to the program are outlined below.

1) One misconception is that each frame is a "test question" demanding only memory rather than understanding. The format, coupled with previous test experience, leads to this misconception. It must be made clear that the purpose of a frame is not to "write an answer", but to learn the material presented in the frame. The response writing and checking is not to "see if you have learned", as much as it is to help with the learning!

2) A second misconception is that the blank in a frame should be filled in "as you go". Generally the entire frame should be read before any response is written. Certainly the entire sentence containing the blank must be read prior to response. Also, the frame should be re-read and considered after the responses are written and before they are checked. Any incorrect response should be carefully considered by the student. If he cannot determine why his response is incorrect, he may either

   a) immediately ask for teacher (or other student)help or

   b) proceed with the following frames, where his difficulty may correct itself. A succession of wrong responses demands immediate teacher help. It seems a good idea to have students keep a list of "wrong response frames" so they can call attention to these during question sessions and assign special attention to these during review. While a single wrong response may mean very little, a list of wrong responses may exhibit a pattern which will reveal a great deal about the student's performance.

3) A third misconception is that the purpose of the program is to "race" through the course. This misconception is deadly to learning! It leads to "unthought out" responses and "pre-response checking"--that is, "cheating!" Constant stress must be placed on the fact that the purpose of the course is to learn--the program is to aid this. Of course, students should be encouraged to do as many frames as possible in a given time but not at the expense of proper study procedure! Slower students may need to spend additional time on the program. Faster students may need to have work provided outside the program. But no "frames per hour" schedule will work to the advantage of the programming method and may very well destroy its usefulness.

4) A fourth misconception is that the programmed material is simply a replacement for an ordinary textbook. This particular misconception leads to complaints of "excessive repetition", "slow progress within the material", "boring", and so on. The student's pre-program reading experience has been with "books which tell" not "books which teach". The ordinary textbook is designed to provide only the first phase of the learning process--dissemination of correct information. It leaves the "fixing" of this information to other classroom media--discussion, lecture, etc. The program is much

more a "self-contained" learning device. The students must realize that the program replaces the textbook, the "lecture", and much of the discussion. Compared with the the textbook, it does progress slowly, and it is repetitious. However, compared with the total traditional learning experience, it is quite "brisk" and efficient! It is this latter comparison which is valid. This fact must be stressed--and periodically re-stressed to students.

5) A fifth misconception is that when students are executing frames, one need have only a "classroom monitor" or study-hall teacher circulating about because all the material is self-contained. Actually, a highly competent teacher is needed to handle individualized instruction due to the constant need for diagnosing individual needs.

B. It is important that provision be made for aid in clearing up "wrong response" problems. This can be done in a number of ways:

1) The teacher can answer individual questions as they arise.

2) The teacher can provide for short sessions with groups of four to eight students (preferably of comparable ability) each day. Here, in addition to student questions, teacher initiated questions and discussions result. With the typical programmed instructional Teachers Manual, a list of possible "trouble-spots" is included. These lists will point out topics for which a teacher-student discussion is desirable in conjunction with the programmed material.

3) A part of each period may be taken for class-wide discussion of student questions. This is somewhat difficult, for questions beyond the point in the program where a particular student is working are meaningless to him. However, slower students, in general, have more questions. Hence, the session is more likely to provide for a continual review for the faster students.

4) Often faster students can serve as "assistant teachers" for part of each day or for one day per week, and the teacher and his "assistants" can work according to either (1) or (2). This is a partial solution to the "individual rate" problem we will discuss later and also provides excellent review for faster students (and may, incidentally, "recruit" some future teachers!).

Providing for Variable Rates of Progress

It is important that pre-planning be done to provide for varying rates of progress. Much has been said about "individual differences", "ability grouping", and the like. Every teacher is aware of the problems produced by the "ability span" within the average "ungrouped" class. However, a new realization of just how great this span is will be provided when students are given material which allows individual differences to be exhibited! It is paradoxical that the situation of "progress by ability", which we all feel to be ideal, and which is one of the strongest appeals for programmed instructional materials, can itself present problems. These problems are particularly evident in programs with a multi-track feature. There are several methods of establishing a "progress procedure!"

1) One method is to let each student progress at his own rate. While this is educationally sound, it may be administratively troublesome--both within the class and within the school! If this is done with all students working the same amount of time, the "spread" will soon become quite great. The problem with the student who finishes a year's course in eighteen weeks (and it will probably happen!) is one of additional work, etc. The problem with the slow student who successfully completes only part of a course during the year is one of grading and credit. Many schools have solved these administrative problems. Further solutions seem on the horizon, when progress is measured by amount learned rather than hours spent and pages covered! Because this method is educationally preferable, one possibility is to compensate as much as possible for the "spread" by designing three-courses-in-one. If the slower student is permitted to work outside the classroom (where necessary), he should be able to complete the course designed for him.

2) The other extreme from (1) is the "lock-step" system in which day-to-day "frame assignments" are made with homework supplementing classwork to provide for individual differences in progress rate. Such a procedure can reinforce many of the misconceptions listed under (A) and can seriously damage the effectiveness of the programming procedure.

3) Another possibility is that a "happy medium" can be attained. This consists of either "together by unit" or "together by grading period" progress. This necessitates:
    a) Provision for additional work for slower students
    b) Provision for additional "learning activities" for faster students.

   The opportunity for (a) is not difficult. Suggestions for (b) include the "teacher assistant" role previously discussed, introduction of enrichment materials which provide either experience with interesting "outside" topics or, probably better, experience with materials related to topics in the program which provide "deeper" or alternative approaches to these topics. Certainly no single program (nor any one textbook!) includes all a good student might profitably learn about any topic! "Work groups" of faster students, with only occasional teacher participation, is an excellent procedure. If nothing more is provided than good, interesting, additional problems, these, and the opportunity for interaction on an oral basis with "peers", are a valuable educational experience.

4) Perhaps the most dynamic possibility is the use of team teaching techniques with the programmed instructional materials providing the basis for the continual regrouping of students based on the students' progress. The proper blending of the best features of many educational techniques is the ultimate test of professionalism for teachers.

Providing for Review and Evaluation

It is important that provision be made for review and evaluation. These certainly are not new problems inherent in the use of programmed materials! However, these materials do present some unique aspects of the problems. All research indicates that frequent evaluation is necessary--probably at least biweekly. The necessity of this is not for "grade compilation", but rather for "student self-evaluation". There is a need to see progress other than "frame by frame" progress.

The necessity of frequent evaluation has most often been the area in which programmed learning has failed in the past. Teachers, even using student assistants, cannot be expected to grade 20 or 30 tests every class period!

This is where the computer enters in. When a student reaches one of many pre-determined points, he comes to the teacher, gets a copy of the test, and works it out. It is then given to the teacher who feeds it to an optical page reader--right in the classroom! Virtually immediately the test is scored, recorded, and returned with each question individually marked. The teacher than can discuss the outcome with the student and direct the student on the next section or into some review work.

Many possibilities for review must be provided. Periodic oral review sessions have already been discussed. The plan of having students keep lists of "error frames" and using these as the basis for review seems wise. Another review procedure used successfully by some teachers has been to have the student "redo" every third or fifth or tenth frame of the program with the instruction, "when you give an incorrect response (or a frame is "out of context") return to the last frame you completed successfully and work frames in sequence until you 'pass' the one you 'missed'".

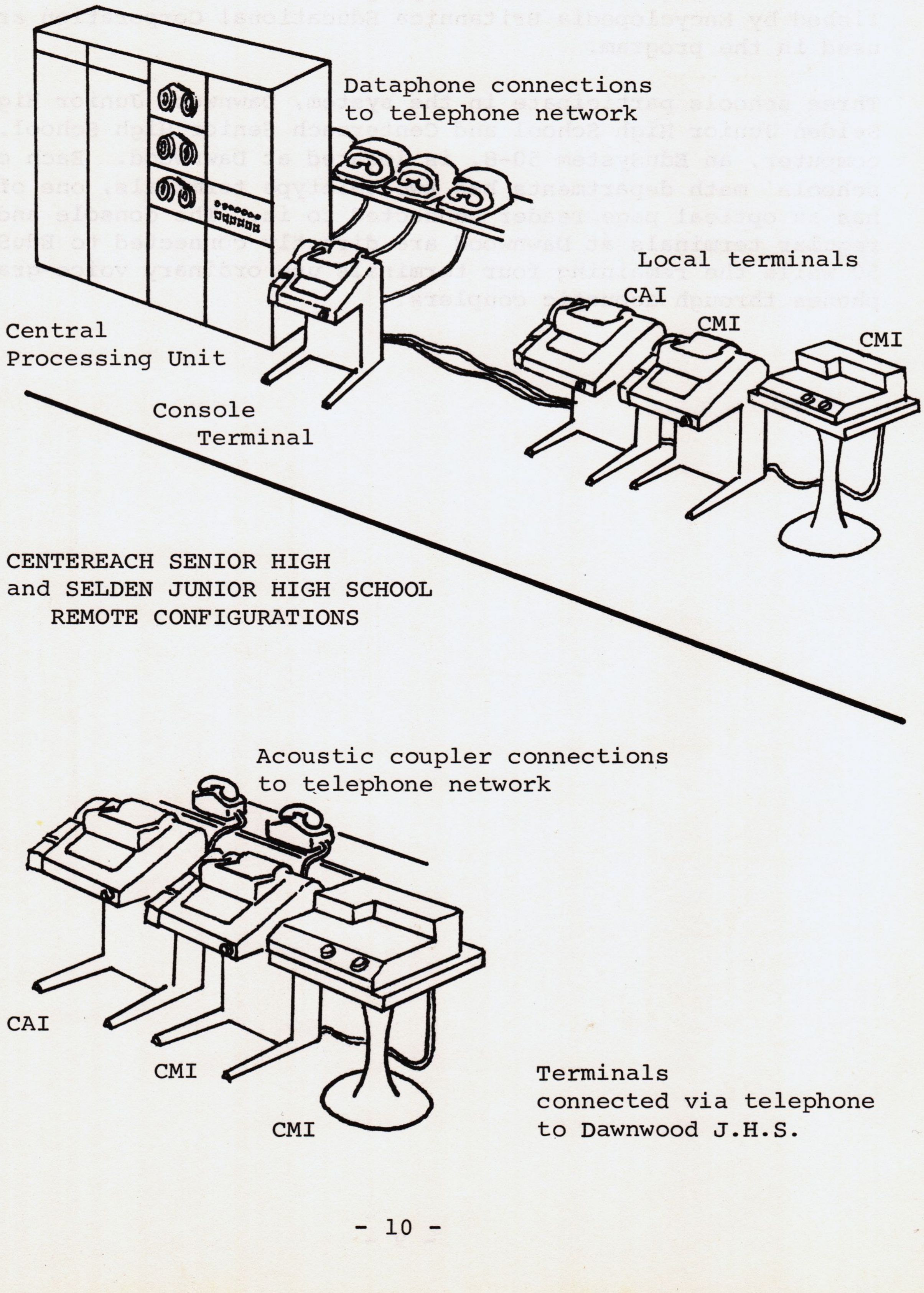
Programmed materials will "solve" many educational problems. They will also provide some new ones of their own. The role of the teacher as "lecturer to all" diminishes. It is replaced by the vital role of "teacher of each!" This discussion of possible procedures is by no means exhaustive. It is meant to communicate existing experience and to generate thought which will give rise to improved procedures in the future. We invite you to contribute to us the ideas which prove successful to you so that they may become a part of the general knowledge about programmed materials and computer managed instruction.

Installation at Middle Country Schools

Rather than describe the DEC CMI system abstractly, a typical installation at Middle Country School District, Centereach, New York will be described. The system at Middle Country covers mathematics, Grades 7 through 9. The TEMAC programmed learning materials published by Encyclopedia Britannica Educational Corporation are those used in the program.

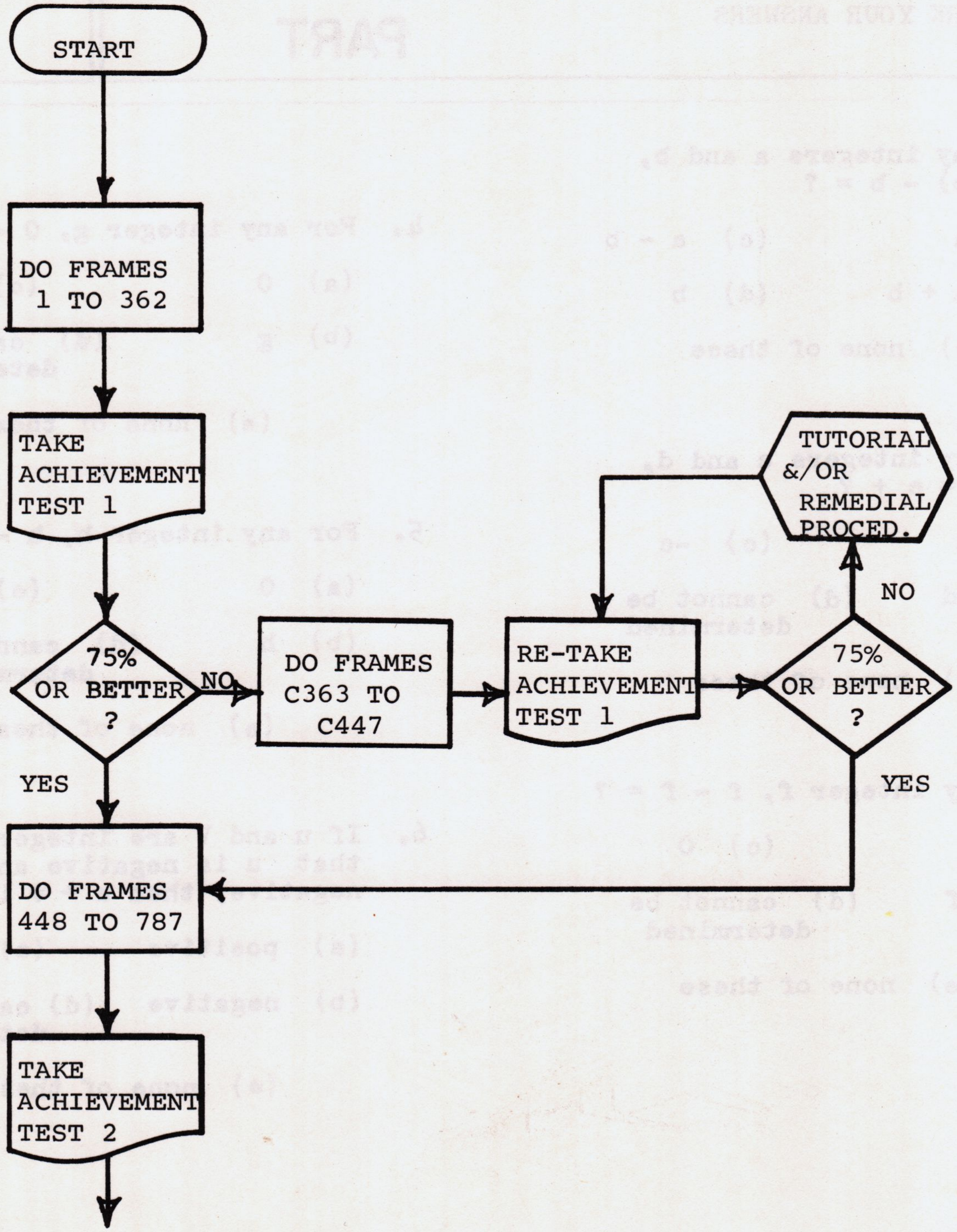
Three schools participate in the system, Dawnwood Junior High School, Selden Junior High School and Centereach Senior High School. The computer, an EduSystem 50-8, is located at Dawnwood. Each of the schools' math departments has two teletype terminals, one of which has an optical page reader connected to it. The console and two regular terminals at Dawnwood are directly connected to EduSystem 50 while the remaining four terminals use ordinary voice-grade telephones through acoustic couplers.

DAWNWOOD JUNIOR HIGH SCHOOL
CENTRAL CONFIGURATION


Dataphone connections to telephone network
Local terminals
CAI
CMI
CMI
Central Processing Unit
Console Terminal
CENTEREACH SENIOR HIGH and SELDEN JUNIOR HIGH SCHOOL REMOTE CONFIGURATIONS
Acoustic coupler connections to telephone network
CAI
CMI
CMI
Terminals connected via telephone to Dawnwood J.H.S.

System Flow Description

The use of the programmed instructional materials is completely described on flow charts similar to the one below. The following pages show a typical page of a typical test and an optically-readable answer sheet.



TEST

DO NOT MARK OR WRITE
ON THIS TEST BOOKLET -
USE ANSWER SHEET ONLY
TO MARK YOUR ANSWERS

PROGRAM 9
TEST NUMBER 2
PART

FORM
MARK THIS LE R
ON ANSWER SHE

A

1. For any integers a and b, (a + b) - b = ?

   (a) a (c) a - b

   (b) a + b (d) b

   (e) none of these

2. For any integers c and d, c - d = c + ?

   (a) d (c) -c

   (b) -d (d) cannot be determined

   (e) none of these

3. For any integer f, f - f = ?

   (a) f (c) 0

   (b) -f (d) cannot be determined

   (e) none of these

4. For any integer g, 0 - g = ?

   (a) 0 (c) -g

   (b) g (d) cannot be determined

   (e) none of these

5. For any integer h, h - 0 = ?

   (a) 0 (c) -h

   (b) h (d) cannot be determined

   (e) none of these

6. If u and V are integers such that u is negative and v is negative, then u + v is:

   (a) positive (c) 0

   (b) negative (d) cannot be determined

   (e) none of these

Ⓐ TO REQUEST A TEST:
Complete this section and section B

0 ☐ 0 ☐ 0 ☐ ☐ 0 ☐ 0 ☐ 0 0 0 0
1 ☐ 1 ☐ 1 ☐ ☐ 1 ☐ 1 ☐ 1 1 1 1
2 ☐ 2 ☐ 2 ☐ ☐ 2 ☐ 2 ☐ 2 2 2 2
3 ☐ 3 ☐ 3 ☐ ☐ 3 ☐ 3 ☐ 3 3 3 3
4 ☐ 4 ☐ 4 ☐ ☐ 4 ☐ 4 ☐ 4 4 4 4
5 ☐ 5 ☐ 5 ☐ ☐ 5 ☐ 5 ☐ 5 5 5 5
6 ☐ 6 ☐ 6 ☐ ☐ 6 ☐ 6 ☐ 6 6 6 6
7 ☐ 7 ☐ 7 ☐ ☐ 7 ☐ 7 ☐ 7 7 7 7
8 ☐ 8 ☐ 8 ☐ ☐ 8 ☐ 8 ☐ 8 8 8 8
9 ☐ 9 ☐ 9 ☐ ☐ 9 ☐ 9 ☐ 9 9 9 9

YOUR STUDENT NUMBER ☐☐☐☐☐☐

SCHOOL ☐☐

PERIOD ☐☐

PROGRAM ☐☐

TEST NUMBER ☐☐

PART ☐

In the large boxes print the information requested, then in the column above each box mark-sense the red position that represents the same value.

A SEP ☐
B OCT ☐
C NOV ☐ 0
D DEC ☐ 1 ☐ 1
E JAN ☐ 2 ☐ 2
F FEB ☐ 3 ☐ 3
G MAR ☐ 4
H APR ☐ 5
I MAY ☐ 6
J JUN ☐ 7
K JUL ☐ 8
L AUG ☐ 9

TEST FORM ☐

MONTH ☐☐ DAY

Ⓒ

Complete this section ONLY when taking your test.

WT. ☐
KEY ☐
CLASS ☐

0 0
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9

☐☐

Ⓓ

DO NOT MARK IN THIS SECTION

1 A B C D E
2 ☐ ☐ ☐ ☐ ☐
3 ☐ ☐ ☐ ☐ ☐
4 ☐ ☐ ☐ ☐ ☐
5 ☐ ☐ ☐ ☐ ☐
6 A B C D E
7 ☐ ☐ ☐ ☐ ☐
8 ☐ ☐ ☐ ☐ ☐
9 ☐ ☐ ☐ ☐ ☐
10 ☐ ☐ ☐ ☐ ☐
11 A B C D E
12 ☐ ☐ ☐ ☐ ☐
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14 ☐ ☐ ☐ ☐ ☐
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20 ☐ ☐ ☐ ☐ ☐
21 A B C D E
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24 ☐ ☐ ☐ ☐ ☐
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46 A B C D E
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49 ☐ ☐ ☐ ☐ ☐
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51 A B C D E
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54 ☐ ☐ ☐ ☐ ☐
55 ☐ ☐ ☐ ☐ ☐
56 A B C D E
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58 ☐ ☐ ☐ ☐ ☐
59 ☐ ☐ ☐ ☐ ☐
60 ☐ ☐ ☐ ☐ ☐

If test is more than 60 answers mark-sense ☐ this position

Ⓑ TO REQUEST A TEST: Complete this section and section A

NAME ______________________, ______________________
(LAST) (FIRST)

CLASS TEACHER ______________________ ROOM ______ CLASS ______

CLASS DAYS ______

61 A B C D E
62 ☐ ☐ ☐ ☐ ☐
63 ☐ ☐ ☐ ☐ ☐
64 ☐ ☐ ☐ ☐ ☐
65 ☐ ☐ ☐ ☐ ☐
66 A B C D E
67 ☐ ☐ ☐ ☐ ☐
68 ☐ ☐ ☐ ☐ ☐
69 ☐ ☐ ☐ ☐ ☐
70 ☐ ☐ ☐ ☐ ☐
71 A B C D E
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89 ☐ ☐ ☐ ☐ ☐
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116 A B C D E
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121 A B C D E
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146 A B C D E
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151 A B C D E
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156 A B C D E
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161 A B C D E
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166 A B C D E
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175 ☐ ☐ ☐ ☐ ☐
176 A B C D E
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179 ☐ ☐ ☐ ☐ ☐
180 ☐ ☐ ☐ ☐ ☐

Computer Software System

Within each class, students will be assigned to work in a selected program. The programs in junior high school are numbered 7,8,9, and 10; within each program group, there could be as many as 15 distinct classes. Students are assigned to these supplementary classes according to the pace of their achievement, so that each class consists only of students at approximately the same point in the program.

In general, students will receive instruction via their execution of a programmed text. They will periodically (about once a week) make a request to take a test. Those students who request tests will fill in section (A) of the test answer sheet. Using the VERIFY program, a teacher-aide will run each request through the optical page reader. The VERIFY program checks whether or not the requested test has already been taken. If it has, the teacher-aide will issue a "FORM" number of the test which the student has never taken. If the test has never been taken, any "FORM" can be issued. The test answer sheet and a copy of the test are clipped together to be given to the student on the following day.

The class period is 40-50 minutes in duration. During any one class period, about 30 students will be taking tests. Test duration will be about 30 minutes. This allows 10-20 minutes to score all tests before the period ends. The SCORE program is used to perform this task. It provides an immediate printout to the student and stores the result in a temporary disk file.

At a convenient time later in the day, the DECtape which contains the student files for a particular school-period is mounted and the TRANSF program is used to update the student files from the temporary disk files.

The Record Analysis program (ANALY1) is executed at appropriate intervals to group the students according to certain criteria. The report output is sorted in such a manner as to provide a new grouping of students for reassignment to new supplementary classes.

The Student File Edit (SFEDIT) program is then used to correct the "supplementary class field" number in the vital information block of each student and the cycle starts again.

The software package consists of nine programs, all operating under the EduSystem 50 standard timesharing monitor.

CREATE--Sets Student File DECtape format

1. Writes file header (school and period)
2. Resets bit map (block availability)
3. Reserves Student Directory blocks

UPDATE--Student File DECtape Maintenance

1. Inserts names of new students
2. Deletes student names
3. Return math blocks to free file

SFEDIT-Student File Editor

1. Correct student's vital information block
2. Correct and delete math tests
3. Allows addition of supplemental information on students

KEYWT-Test Key File Maintenance

1. Insert and/or correct Test keys
2. Insert and/or correct Test Weights

SCORE-Score Tests

1. Store test results in temporary disk files

TRANSF-Update Test Results to Student File DECtape

1. Report output of update.

ANALY1-Student Record Analysis

1. Search student file for students who fall within limits entered at keyboard.
2. Sort collected set according to keyed parameters.
3. Report output of collected set.

VERIFY-Verify test forms for students requesting tests

1. Enter test number.
2. Search DECtape to ensure that student has not taken test previously.

REPORT-Report output of all tests taken of all students in a particular supplementary class.

Class Scheduling, Teaching and Cost Justification

Unlikely topics to consider together? Let's see. In a traditional junior high math program, Grades 7 through 9, with say 1000 students, a school would probably employ 8 teachers teaching 5 periods a day with 25 students per class. Generally, one teacher aid would be allowed for also.

TRADITIONAL SCHEDULE--GRADES 7-9 MATH

Monday through Friday Schedule

	. . . . . . .Period.				
Teacher	1	2	3	4	5
1	25	25	25	25	25
2	25	25	25	25	25
3	25	25	25	25	25
4	25	25	25	25	25
5	25	25	25	25	25
6	25	25	25	25	25
7	25	25	25	25	25
8	25	25	25	25	25

Team teaching and other techniques may be employed but, in general, one would still have a schedule similar to that above. Any progress toward individual learning must be incorporated into this fairly rigid defined structure. Redefining or reallocating students in sections can be done conveniently only at the beginning of a new term. Teachers, therefore, will be faced with the problem of having students with very different learning rates in the same section. By the end of the term, this problem can become quite pronounced.

Using Computer Managed Instruction, an administrative and grading mechanism is available which allows for periodic re-allocation of students in sections. Furthermore, since students are working on programmed learning materials independently much of the time, this activity can be done in larger sections. The schedule used at Middle Country Schools is as follows:

CMI SCHEDULE--GRADES 7-9 MATH

Monday, Wednesday Schedule*

		. . . . . .Period.				
	Teacher	**1**	**2**	**3**	**4**	**5**
Standard Class	1	25	25	25	25	25
	2	25	25	25	25	25
	3	25	25	25	25	25
	4	25	25	25	25	25
Independent work on PI material	5+Aid	70	70	70	70	70
Take Test	6+Aid	30	30	30	30	30

*On Tuesdays and Thursdays the first and second major groups of students are interchanged.

Because re-allocation of students keeps class sections very similar in achievement level and learning rate, students can be much more effectively taught. Furthermore, since teachers are relieved of arduous administrative test-giving and grading chores, they are able to spend all their time teaching.

Cost justification? Annual lease costs of the system are more than covered by having two fewer teachers in each of three schools. Of course, some school systems are apt to go to smaller class sections and retain all their teachers. No matter which approach is taken, the increased educational value more than justifies the cost of the CMI system.

In Addition

The heart of the CMI computer system is a powerful time sharing, resource sharing EduSystem 50 based on the popular PDP8/E computer.

This computer provides for up to 16 terminals in total which may be divided between CMI and student use. Student terminals may be used to provide drill and practice exercises, for student problem solving, for programming instruction, for running simulations (models, games), and for a host of other student functions.

For information about these applications, the following DEC publications are recommended.

Computer are for Kids, Not for Geniuses
EduSystems 10-50 Product Catalog
A Landmark Year for Computers in High Schools (reprint)
Computing - New Interest in Schoolwork (reprint)
The Computer Comes into the Classroom

System Costs

	Purchase	Monthly Lease*	Monthly Maintenance
Computer System (EduSystem 50)	$71,000	$1,620	$700
16K memory			
262K disk			
4 DECtape units			
CMI Test Grading Station			
Local (each)	6,400	146	70
Remote (each)	7,300	166	79
Time Sharing Terminal For Student Use			
Local (each)	1,800	42	30
Remote (each)	2,700	62	39
On-site Training and Installation	2,500	-	-
Typical System for 3 Schools			
1 Central Computer System	$71,000		
1 Local CMI Station	6,400		
2 Remote CMI Stations	14,600		
1 Local Time Sharing Terminal	1,800		
2 Remote Time Sharing Terminals	5,400		
Training and Installation	2,500		
Total	$101,700	$2,264	$1,020

* 5-year full-payout lease

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